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FARGO - MOORHEAD
AIR POLLUTANT EMISSION INVENTORY

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A summary is presented of the emission inventory for the Fargo - Moorhead Metropolitan Area. The report provides estimates of the present levels of air pollutant emissions and the status of their control. The pollutants which include sulfur oxides, particulates, carbon monoxide, hydrocarbons, and nitrogen oxides are delineated with respect to source type, season of the year, and geographical distribution within the area. The Study Area which was chosen on the basis of the distribution of population and air pollution sources, consists of two counties surrounding the cities of Fargo and Moorhead. A grid coordinate system was used to show the geographical distribution of emissions within counties. All sources of emissions were classified into five categories: transportation, stationary fuel combustion, solid-waste disposal, industrial processes, and evaporative losses.

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FARGO-MOORHEAD METROPOLITAN AREA AIR POLLUTANT EMISSION INVENTORY REPORT

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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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Minnesota Pollution Control Agency

North Dakota Air Pollution Control Program

PREFACE

This report, which presents the emission inventory for the Fargo-Moorhead Metropolitan Area, is another in a series of surveys outlining the sources and emissions of air pollutants for major metropolitan areas in the country. These surveys, conducted by the National Inventory of Air Pollutant Emissions and Control Branch of the National Air Pollution Control Administration, provide estimates of the present levels of air pollutant emissions and status of their control. The pollutants, which include sulfur oxides, particulates, carbon monoxide, hydrocarbons, and nitrogen oxides, are delineated with respect to source type, season of the year and geographical distribution within the area. The general procedure for the surveys is based upon the rapid survey technique for estimating air pollutant emissions.[1] These reports are intended to serve as aids in the proposing of boundaries of Air Quality Control Regions, as directed by the Air Quality Act of 1967.

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INTRODUCTION

This report is a summary of the Fargo-Moorhead air pollutant emission inventory conducted in December, 1969. Since all inventories are based upon a calendar year, the data and emission estimates presented are representative of 1968 and should be considered as indicating the conditions as existed during that year.

The Study Area, which was chosen on the basis of the distribution of population and air pollution sources, consists of two counties surrounding the cities of Fargo and Moorhead. This area covers approximately 2,800 square miles and had a 1968 population of 111,500.

A grid coordinate system was used to show the geographical distribution of emissions within counties. The Study Area was subdivided into 34 grid zones ranging in size from 25 square kilometers in the heavily populated and industrialized areas to 400 square kilometers in the rural areas.

All sources of emissions were classified into five categories--transportation, stationary fuel combustion, solid-waste disposal, industrial processes and evaporative losses. Each of these source categories was divided into two subgroups--point sources and area sources. Facilities, which emit large quantities of air pollutants, were considered individually as point sources, while the many remaining contributors such as motor vehicles, residential and commercial fuel users, small industries and on-site refuse burning equipment, were considered collectively as area sources. For this report, sixty individual sources, which had emissions greater than 0.1 tons per average annual day for any pollutant, were classified as point sources.

Emissions were estimated by using various indicators such as fuel consumption, refuse burning rates, vehicle-miles, production data, and control efficiencies and emission factors relating these indicators to emission rates.[2] These factors represent average emission rates for a particular source category. Since individual sources have

inherent differences that cannot always be taken into consideration, discrepancies between the actual and estimated emissions are more likely in individual sources than in the total emissions for a source category.

As in all emission surveys, the data presented are estimates and should not be interpreted as absolute values. The estimates are, in some cases, partial totals due to the lack of emission factors and production or consumption data. Despite these limitations, these estimates are of sufficient accuracy and validity in defining the extent and distribution of air pollutant emissions in the Study Area.

SUMMARY

The annual emissions as estimated by the Fargo-Moorhead Metropolitan Area Air Pollutant Emission Inventory are:

Sulfur Oxides	6,800
Particulates	33,200
Carbon Monoxide	50,300
Hydrocarbons	11,100
Nitrogen Oxides	6,600

The following is a brief description of the air pollutant emissions as presented in Table 1 and Table 2.

Sulfur Oxides — The largest portion of the sulfur oxides emitted in the Study Area came from three individual sources. The largest source, a steam-electric utility in Cass County, emitted approximately 28 percent of the total sulfur oxides. Two other large sources, a sugar beet plant in Clay County and a university in Cass County emitted over 42 percent of the total sulfur oxides. This can easily be explained since these three sources consumed over 97 percent of the total coal utilized by all sources. The remaining individual sources together with the area sources emitted 30 percent of the 6,800 tons of sulfur oxides.

Particulates — Nearly fifty feed and grain elevators in the Study Area contributed about 53 percent of total particulates emitted. The three large coal users contributed an additional 39 percent. The remaining individual sources

together with the area sources emitted only 8 percent of the 32,200 tons of particulates.

Carbon Monoxide

Motor vehicles contributed 86 percent of the carbon monoxide emitted annually. Other sources included solid waste disposal and railroads and aircraft which accounted for 3.6 and 7.8 percent respectively of total emissions.

Hydrocarbons

The three largest sources of the 11,100 tons of hydrocarbons were motor vehicles, automobile evaporation losses and the storage and handling of gasoline. They contributed 31 percent, 20 percent, and 31 percent, respectively, of total hydrocarbon emissions. The remaining 18 percent was divided among industrial process sources, solid waste disposal, aircraft, and evaporative losses from dry cleaning plants.

Nitrogen Oxides

The two largest sources of nitrogen oxides were stationary fuel combustion and transportation sources accounting for 49 percent and 48 percent, respectively. The other 3 percent was emitted from solid waste disposal sites.

TABLE 1 SUMMARY OF AIR POLLUTANT EMISSIONS IN THE FARGO-MOORHEAD STUDY AREA, 1968 (Tons/Year)

Source Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Transportation					
Road Vehicles	230	400	43,180	3,450	2,670
Other	60	220	3,930	960	530
Subtotal	290	620	47,110	4,410	3,200
Stationary Fuel Combustion					
Industry	1,620	6,430	150	50	1,210
Steam-Electric	1,900	4,480	20	10	1,000
Residential	800	150	30	50	290
Commercial and Institutional	2,150	2,390	800	170	690
Subtotal	6,470	13,450	1,000	280	3,190
Refuse Disposal					
Incineration	30	130	550	10	40
Open Burning	10	230	1,240	440	160
Subtotal	40	360	1,790	450	200
Process Losses	0	18,800	360	0	0
Evaporative Losses	--	--	--	5,950	--
TOTAL ALL SOURCES*	6,800	33,200	50,300	11,100	6,600

*Totals have been rounded.

TABLE 2 PERCENTAGE CONTRIBUTION OF EACH SOURCE CATEGORY TO TOTAL EMISSIONS IN THE FARGO-MOORHEAD STUDY AREA

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Transportation					
Motor Vehicles	3.4	1.2	85.9	31.1	40.5
Other	.8	.7	7.8	8.7	8.1
Subtotal	4.2	1.9	93.7	39.8	48.6
Stationary Fuel Combustion					
Industry	23.8	19.3	.3	.5	18.3
Steam-Electric	28.0	13.5	N	.1	15.2
Residential	11.7	.4	N	.5	4.4
Commercial and Institutional	31.7	7.2	1.6	1.5	10.4
Subtotal	95.2	40.5	2.0	2.6	48.4
Solid Waste Disposal					
Incineration	.4	.4	1.1	.1	.6
Open Burning	.2	.7	2.5	3.9	2.4
Subtotal	.6	1.1	3.6	4.0	3.0
Industrial Processes	--	56.5	.7	--	--
Evaporative Losses					
Dry Cleaning	--	--	--	2.2	--
Automobile	--	--	--	20.3	--
Gasoline Storage and Handling	--	--	--	31.1	--
Subtotal	--	--	--	53.6	--
TOTAL ALL SOURCES	100	100	100	100	100

N = Negligible

DESCRIPTION OF STUDY AREA

The Study Area for the emission survey of the Fargo-Moorhead Metropolitan Area consists of two counties--Cass County, North Dakota and Clay County, Minnesota. The two-county area is located on the mid-eastern border of North Dakota and the mid-western border of Minnesota. Figure 1 shows the location of the Fargo-Moorhead Study Area relative to other large cities in its vicinity.

Figure 2 represents a more detailed drawing of the Fargo-Moorhead Study Area, showing the boundaries of the urban areas of Fargo, West Fargo, and Moorhead. The Study Area occupies 2,800 square miles and contains an estimated 1968 population of 111,500 which is approximately a 5 percent increase since 1960 (Table 3).

TOPOGRAPHY

The terrain of the Fargo-Moorhead area is very flat with no natural obstructions to hinder the movement of weather systems. The Red River forms a natural boundary between Fargo-Cass County and Moorhead-Clay County.

CLIMATOLOGY

The meteorological conditions in the Fargo-Moorhead Study Area are not influenced by major natural features such as mountains or large bodies of water. The winters are generally long and very cold. Summers are hot. Spring and fall are characterized by moderate temperatures.

MAJOR INDUSTRIAL FACTORS

Table 4 shows selected manufacturing establishments in the Study Area by county for 1963.[3] There is no heavy industry in the area.

Figure 1. Map of the Fargo-Moorhead Study Area and Surrounding Cities

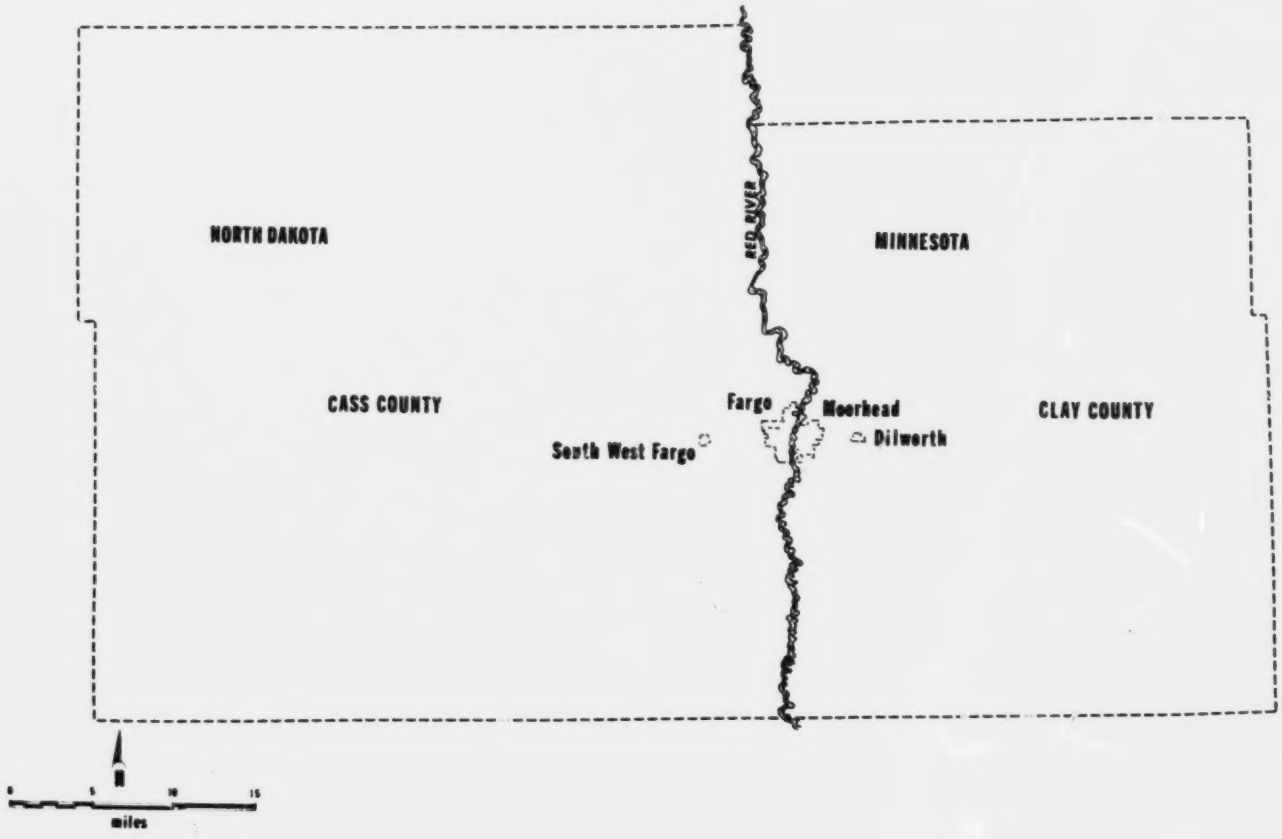

Figure 2. Detailed Map of the Fargo-Moorhead Study Area

TABLE 3 AREA AND POPULATION CHARACTERISTICS FOR THE FARGO-MOORHEAD STUDY AREA

County	Land Area (Sq. Mi.)	Population 1960	Population 1968	Population Density (1968)
Cass County	1,749	66,900	71,000	41
Clay County	1,050	39,100	40,500	39
Total Study Area	2,799	106,000	111,500	40

TABLE 4 SELECTED MANUFACTURING ESTABLISHMENTS IN THE FARGO-MOORHEAD STUDY AREA

Type of Establishment	Number of Establishments by County		
	Cass	Clay	Study Area
Food and Tobacco	8	4	12
Paper and Printing	4	1	5
Metal Products	1	--	1
Stone, Clay and Glass	1	1	2
Chemicals, Petroleum, Rubber and Plastics Products	--	1	1
TOTAL	14	7	21

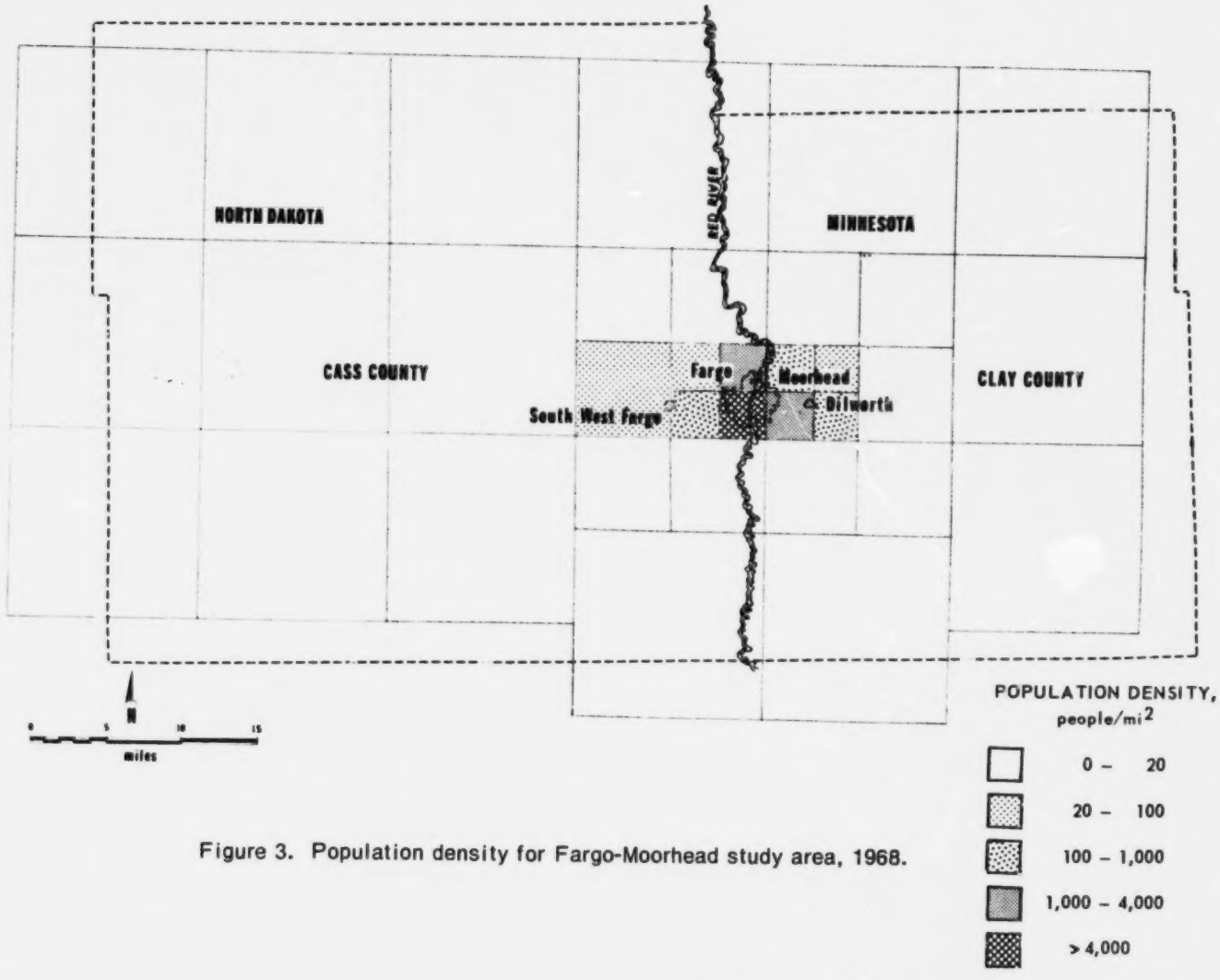

Figure 3. Population density for Fargo-Moorhead study area, 1968.

GRID COORDINATE SYSTEM

A grid coordinate system, based on the Universal Transverse Mercator Projection (UTM) was used in the Fargo-Moorhead Study Area to show the geographical distribution of emissions. A map of this grid system is presented in Figure 4.

The UTM system was chosen due to its advantages over other standard grid systems such as the Latitude-Longitude and State Plane Coordinate Systems. The major advantages of this system are that (1) it is continuous across the country and is not hindered by political subdivisions, (2) the grids are of uniform size throughout the country, (3) it has world-wide use, and (4) the grids are square in shape--a necessary feature for use in meteorological dispersion models.

The Universal Transverse Mercator Projection is based upon the metric system. Each north-south and east-west grid line, as illustrated in Figure 4, is identified by a coordinate number expressed in meters. Each point source and grid are identified by the horizontal and vertical coordinates of their geographical center to the nearest 100 meters.

Grid zones of different sizes are used to limit the number of grid zones and yet allow a satisfactory definition of the geographical gradation of emissions. The majority of the emissions is usually concentrated in the populated and industrialized portions of a Study Area. Smaller grids are placed over these areas in order to reflect abrupt changes in emissions within short distances. The use of grid zones smaller than 25 square kilometers is not warranted because of the inherent inaccuracies in the data. Since only a small percentage of the total emissions occur in rural areas, larger grid zones are normally used to show the distribution of emissions in these lightly populated portions of a Study Area.

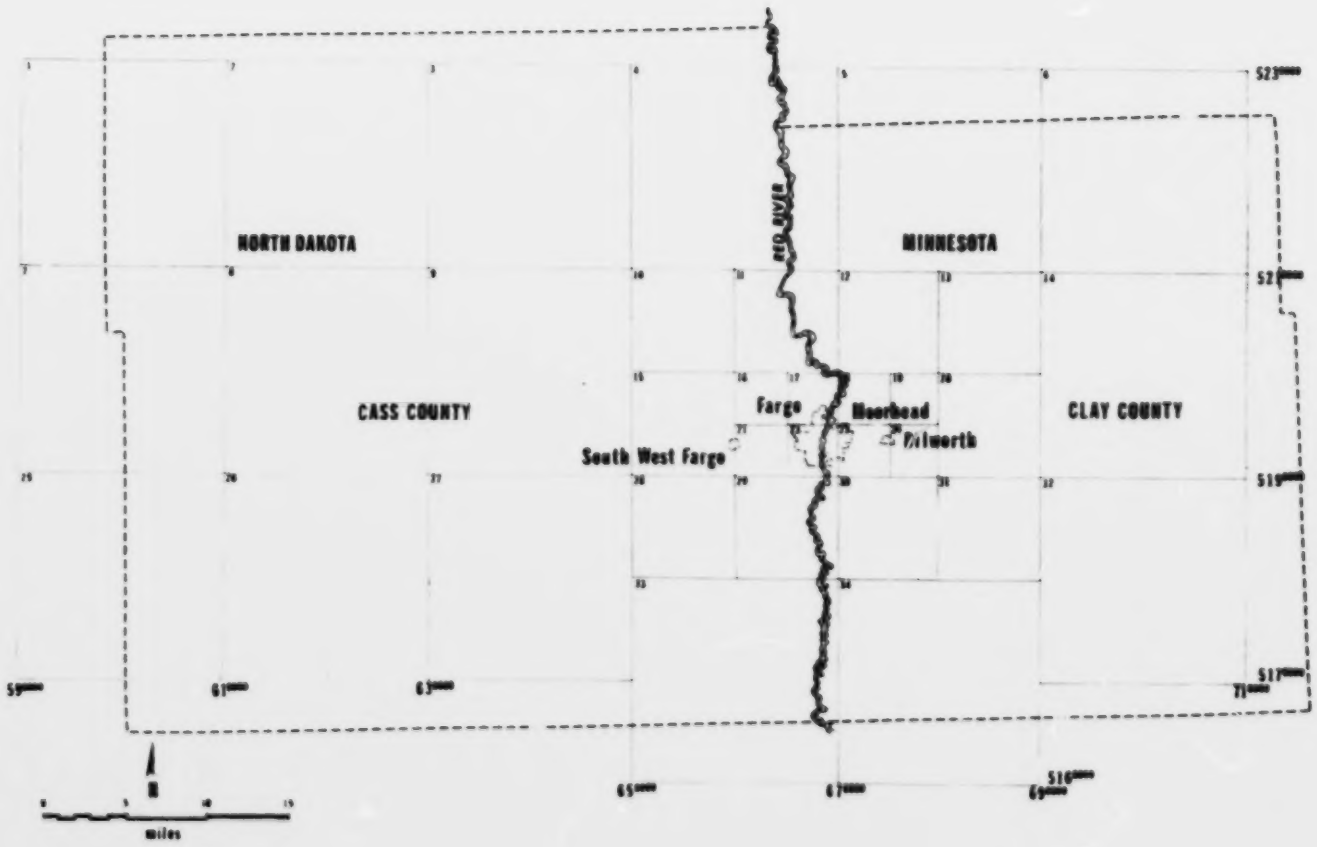

Figure 4. Grid Coordinate System for the Fargo-Moorhead Study Area

EMISSIONS BY CATEGORY

For the purposes of compiling the basic data and emission estimates, the air pollutant sources were classified into the following five categories:

1. Stationary fuel combustion
2. Transportation
3. Solid Waste Disposal
4. Industrial Processes
5. Evaporative Losses

Each of these categories is considered individually in this section where data sources are given and methods of calculation discussed.

STATIONARY FUEL COMBUSTION

The stationary fuel combustion category is concerned with any fixed source which burns fuels for either space heating or process heating. The four primary sources in this category are industrial facilities, steam-electric plants, residential housing, and commercial and institutional establishments. Table 5 presents a summary of the fuels consumed in the Study Area, and Table 6 provides an average chemical analysis of these fuels.

Steam-Electric Utility

METHODOLOGY: Data on the one power plant in the area was acquired from the Northern States Power Company. The data included the annual fuel consumption for 1968, type and efficiency of control equipment, sulfur and ash content of the coal used and the type of furnace.

RESULTS: The steam-electric generating plant in Fargo consumed over 43 percent of the total coal utilized by all sources. Mechanical air pollution controls are utilized on half the boilers and have efficiencies of about 90 percent. Air pollutant emissions from this plant as well as from all other fuel combustion sources are summarized in Table 7.

TABLE 5 ANNUAL FUEL CONSUMPTION IN POLITICAL SUBDIVISIONS OF THE FARGO-MOORHEAD STUDY AREA, 1968

Fuel	Jurisdiction	Industry	Steam-Electric	Residential	Commercial and Institutional	Total
Natural Gas (Million Cubic Feet/Year)	Cass	682	--	1,054	850	2,586
	Clay	261	10	409	372	1,052
	Total	943	10	1,463	1,222	3,638
Coal (Tons/Year)	Cass	N	100,150	N	26,400	126,550
	Clay	101,000	--	N	5,000	106,000
	Total	101,000	100,150	N	31,400	232,550
Fuel Oil (1000 Gal./Year)	Cass	1,174	--	21,086	7,000	29,260
	Clay	1,500	--	12,350	6,600	20,450
	Total	2,674	--	33,436	13,600	49,710

N = Negligible

TABLE 6 SULFUR AND ASH CONTENT OF FUELS, 1968

Fuel	Percent Sulfur	Percent Ash
Coal	3.0	10.7
Residual Oil	1.5	--
Distillate Oil	0.3	--
Natural Gas	0.0008	--

TABLE 7 AIR POLLUTANT EMISSIONS FROM COMBUSTION OF FUELS IN STATIONARY SOURCES IN THE FARGO-MOORHEAD STUDY AREA, 1968

(Tons/Year)

Fuel User Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Coal					
Industrial	1,540	6,400	150	50	1,010
Steam-Electric	1,900	4,490	30	10	1,000
Residential	N	N	0	0	0
Commercial and Institutional	1,790	2,280	780	160	130
Subtotals*	5,230	13,170	960	220	2,140
Fuel Oil					
Industrial	80	20	N	N	100
Steam-Electric	N	N	N	N	N
Residential	800	130	30	50	200
Commercial and Institutional	360	100	10	10	490
Subtotals*	1,240	250	40	60	790
Gas					
Industrial	N	10	N	0	100
Steam-Electric	N	N	N	0	N
Residential	N	10	N	0	90
Commercial and Institutional	N	10	N	0	70
Subtotals*	N	30	N	0	260
GRAND TOTALS*	6,470	13,450	1,000	280	3,190

*Totals have been rounded.

N = Negligible

Industrial

METHODOLOGY: Fuel consumption data were obtained for only the largest industries in the Study Area. However, the bulk of the fuels used by industry were consumed by these plants. This data was provided by the local air pollution agencies which had contacted each plant.

In order to obtain the balance of the fuel being used in the Study Area, fuel associations and fuel dealers were contacted by the local agencies. The fuel consumption data from the largest plants were deducted from the total fuel and the combustion of the remaining fuel was considered an area source. This industrial area fuel consumption was apportionned into grids based on industrial land use.

It should be noted that fuel combustion by industries includes both fuel used for space heating, and fuel used for process heating. The individual sources contacted were asked to differentiate between these two uses giving the percentage used for each purpose. A national average, however, was used to separate process heating from space heating in the area sources.

RESULTS: From Table 5 it was shown that over 43 percent of the total coal, 25 percent of the natural gas and less than 6 percent of the fuel oil were used in industrial operations. The largest industrial fuel user is a sugar beet plant in Clay County. The resulting emissions from this fuel combustion are summarized in Table 7.

Residential

METHODOLOGY: Natural gas and fuel oil, for all practical purposes, were the only fuels used for residential home heating.[4] There were homes heated by other fuels, but they represent a very small percentage of the total. Data on the amount of natural gas used for domestic heating was supplied by the local power company. Fuel oil data was obtained from the Northwest Petroleum Association and an annual report on petroleum products published by the state of North Dakota.[5]

RESULTS: The emissions from residential sources were insignificant except for sulfur oxides, for which 12 percent of the total fuel combustion emissions were from home heating.

Commercial and Institutional

METHODOLOGY: Commercial and institutional establishments used coal in addition to natural gas and fuel oil. Data on the amount of natural gas and fuel oil used were obtained from the same sources as residential. Coal data were obtained from the individual users and coal dealers in the area.

RESULTS: Sulfur oxide emissions from commercial and institutional sources accounted for about 32 percent of the total fuel combustion emissions. This results from the combustion of a large amount of coal.

TRANSPORTATION

Three types of transportation sources of air pollution are considered in this survey--motor vehicles, aircraft, and railroads. Motor vehicles, which are by far the most significant source in this category, are further subdivided according to type of fuel--gasoline or diesel.

Motor Vehicles

More than 1.5 million miles per day were traveled by motor vehicles in 1968 in the Fargo-Moorhead Study Area. Table 8 shows the miles of travel for gasoline and diesel vehicles for each county in the Study Area.

Vehicle-mile data for essentially all of the roads in Cass County were supplied by the North Dakota State Highway Department.[6] The vehicle miles were transferred onto the previously mentioned grid system. In Clay County vehicle-mile information was not available, and thus gasoline consumption was used to find vehicular emissions.

The contribution to the total motor vehicle pollution by diesel-powered vehicles was determined by data supplied by the North Dakota State Highway Department. Diesel-powered vehicles accounted for approximately 5 percent of the total vehicle miles in the country and about 1 percent in the city.

Emissions from road vehicles are a function of the speed at which the vehicle travels. Average speeds of 10-20 mph were assumed for downtown areas, 20-30 mph for the residential area, and 30-45 mph for the rural

areas to calculate vehicle emissions.

From all transportation sources, road vehicles accounted for 80 percent of the sulfur oxides, 64 percent of the particulates, 92 percent of the carbon monoxide, 78 percent of the hydrocarbons, and 84 percent of the nitrogen oxides. Gasoline powered motor vehicles contributed a greater percent of all pollutants than diesel powered motor vehicles. Emissions from transportation sources are summarized in Table 9.

Aircraft

Table 10 shows the air traffic activity at the only airport in the Study Area. An estimate of the number of flights by engine type was supplied by the traffic controller at the airport and summarized in Table 11.

The air pollutant emissions from aircraft include all phases of operation (taxi, take-off, climb out, approach and landing) that take place below the arbitrarily chosen altitude of 3,500 feet. Emissions at cruise altitude (above 3,500 feet) are not of concern in an emission inventory. From all transportation sources, aircraft accounted for 11 percent of the particulates, 8 percent of the carbon monoxide, 17 percent of the hydrocarbons and 6 percent of the nitrogen oxides.

Railroads

Railroad operations (mainly locomotive) consume more than 2 million gallons of diesel fuel per year within the Study Area. This quantity is about 30 percent as much as the amount of diesel fuel consumed by motor vehicles. The majority of this fuel is consumed during switching operations. Diesel fuel consumption data were supplied by each of the major railroads in the Fargo-Moorhead area.

Railroad operations contribute about 25 percent of the particulates from all transportation sources, 20 percent of sulfur oxides, and 10 percent of the nitrogen oxides. They account for less than 5 percent of the emissions of carbon monoxide and hydrocarbons.

TABLE 8 VEHICLE MILES OF TRAVEL FOR ROAD VEHICLES IN FARGO-MOORHEAD STUDY AREA PER DAY, 1968

Jurisdiction	(Thousand Miles) Gasoline Vehicle Miles	(Thousand Miles) Diesel Vehicle Miles	Total
Cass	875	29	904
Clay	607	20	627
Total	1,482	49	1,531

TABLE 9 TRANSPORTATION SOURCES IN AIR POLLUTANT EMISSIONS IN THE FARGO-MOORHEAD STUDY AREA, 1968 (Tons/Year)

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Road Vehicles					
Gasoline	160	220	43,080	3,230	2,300
Diesel	70	180	100	220	370
Subtotal	230	400	43,180	3,450	2,670
Aircraft					
Jet	N	50	50	40	40
Piston	N	20	3,780	720	180
Turboprop	N	N	10	N	N
Subtotal	N	70	3,840	770	220
Railroads	60	160	80	190	310
GRAND TOTAL*	290	620	47,140	4,410	3,200

N = Negligible

*Totals have been rounded.

TABLE 10 AIR TRAFFIC ACTIVITY AT HECTOR AIRPORT, 1968

	Itinerant*	Local*
Air Carrier	14,630	--
General Aviation	45,620	62,470
Military	6,860	8,870
TOTAL	67,210	71,340

*Operation take-off or landing

TABLE 11 AIR TRAFFIC ACTIVITY BY ENGINE TYPE FOR FARGO-MOORHEAD STUDY AREA, 1968

Engine Type	Number of Flights*
1 Engine Jet	6,270
2 Engine Jet	950
3 Engine Jet	3,430
4 Engine Jet	150
2 Engine Turboprop	580
4 Engine Turboprop	2,190
1 Engine Piston	39,000
2 Engine Piston	16,200
4 Engine Piston	390
Total	69, 180

*Flight combination take-off and landing

SOLID WASTE DISPOSAL

Approximately 104,000 tons of refuse was generated during 1968 within the Study Area. Table 12 presents a solid waste balance for the Fargo-Moorhead Study Area, showing the various methods of disposal and the quantities disposed of by each method. About half of the refuse was disposed in non-burning dumps. The remainder was disposed of in on-site incineration and open burning in both on-site and dumps. Refuse data for all of the counties were supplied by each air pollution agency.

Incineration

There is only one major category of incineration in the Fargo-Moorhead Study Area--on-site. On-site incineration disposed of 24 percent of the generated refuse. The contribution of on-site incinerators to the total solid waste emissions are shown in Table 13. Fargo-Moorhead does not have any municipal incinerators.

Open Burning

The two major types of open burning are open burning dumps and on-site open burning. The contributions of each of these to total solid waste emissions are shown in Table 13. The largest open burning point sources in the Study Area are 2 open burning dumps in Clay County.

INDUSTRIAL PROCESS LOSSES

The Study Area is void of any heavy industrial complexes. From an air pollution standpoint, a grey iron foundry, sugar beet plant, 47 feed and grain elevators, and 3 asphalt batching plants were the most significant process sources. Table 14 presents a summary of the emissions.

The 47 feed and grain elevators handled over 34 million bushels of feed and grain in 1968. The primary source of dust emissions from these plants is the cleaning operation, which removes the chaff and dirt before

TABLE 12 SOLID WASTE DISPOSAL IN FARGO-MOORHEAD STUDY AREA, 1968 (Tons/Year)

County	Total Refuse Generated	Incineration		Dumps	On-Site	Dumps	Auto Body Burning	Wood Waste Burning
		On-Site	Municipal					
Cass County	69,100	16,000	--	39,500	11,700	1,900	--	--
Clay County	34,700	9,200	--	10,000	6,700	8,800	--	--
Totals	103,800	25,200	--	49,500	18,400	10,700	--	--

TABLE 13 AIR POLLUTANT EMISSIONS FROM SOLID WASTE DISPOSAL IN THE FARGO-MOORHEAD STUDY AREA, 1968 (Tons/Year)

Source Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Incineration					
Municipal	0	0	0	0	0
On-Site	20	130	550	10	40
Subtotal	20	130	550	10	40
Open Burning					
On-Site	10	150	780	280	100
Dump	10	80	460	160	60
Subtotal	20	230	1,240	440	160
GRAND TOTAL*	40	360	1,790	450	200

*Totals have been rounded.

TABLE 14 AIR POLLUTANT EMISSIONS FROM PROCESS LOSS SOURCES IN THE FARGO-MOORHEAD STUDY AREA, 1968 (Tons/Year)

Type of Industry	SOx	Part.	CO	HC	NOx
Asphalt Batching	0	650	0	0	0
Grain Elevators	0	17,500	0	0	0
Grey Iron Foundries	0	250	360	0	0
Sugar Plant	0	400	0	0	0
Total	0	18,800	360	0	0

the grain is processed. Receiving, handling and storage operations also contribute to the dust emissions. Approximately 93 percent of the particulates from all industrial processes are emitted from feed and grain mills.

The grey iron foundry located in Cass County was the only process source of carbon monoxide in the Study Area. It contributed less than 2 percent of the particulates.

The sugar beet plant's process losses constituted about 2 percent of the total industrial particulate emissions.

The 4 asphalt plants produced more than 280,000 tons of asphalt in 1968. Most of the Plants employed low efficiency cyclones. Particulate emissions from asphalt plants account for less than 4 percent of the total industrial process emissions.

EVAPORATIVE LOSSES

Three source categories were considered for evaporative losses--automobiles, gasoline storage and handling, and the manufacture and consumption of solvents. The hydrocarbon emissions from all sources by evaporative losses are shown in Table 15.

Automobiles

Automobile evaporation losses include gas tank and carburetor evaporation and engine crankcase blowby. Since 1963, most new automobiles were equipped with positive crankcase ventilation (PCV)valves that reduce hydrocarbon emissions from the crankcase by about 90 percent. Due to a lag time in the automobile replacement rate, it was assumed that 20 percent of the automobiles were not equipped with PCV valves.

The hydrocarbon emissions from automobiles were calculated from vehicle-mile data and were apportionned onto grids using the same methods as for motor vehicles discussed earlier. Evaporative losses from automobiles accounted for 38 percent of the total hydrocarbon emissions from evaporative losses in the Study Area.

TABLE 15 HYDROCARBON EMISSIONS FROM EVAPORATIVE LOSSES SOURCES IN THE FARGO-MOORHEAD STUDY AREA, 1968 (Tons/Year)

Source Category	Hydrocarbons
Dry Cleaning Plants	220
Automobile	2,280
Gasoline Storage and Handling	3,450
Total	5,950

Gasoline Storage and Handling

There are four major points (excluding evaporation from the motor vehicle) of hydrocarbon emissions in the storage and handling of gasoline. They are:

1. Breathing and filling losses from storage tanks
2. Filling losses from loading tank conveyances
3. Filling losses from loading underground storage tanks at service stations.
4. Spillage and filling losses in filling automobile gas tanks at service stations.

Approximately 200 million gallons of gasoline was stored in the Study Area in 1968. The evaporative losses from this storage and the subsequent handling of the gasoline accounted for 58 percent of the total evaporative losses.

Manufacture and Consumption of Solvents

Since no solvent manufacturing companies were found in Fargo-Moorhead, this category included only the consumption of solvents at dry cleaning plants. Organic solvents emitted from dry cleaning plants were determined by assuming an emission rate of 4 lb/capita/year.[7] The resulting emissions were apportionned onto grids by population. Dry cleaning plants accounted for only 4 percent of the hydrocarbon emissions from evaporative losses in the Fargo-Moorhead area. No estimates were made on the evaporation of solvents from surface coating operations and for industrial and domestic uses.

EMISSIONS BY JURISDICTION

The previous section presented the air pollutant emissions by source category. In order to show the contribution of each county to the pollution in the entire Study Area, their emissions are summarized in Tables 16 and 17.

TABLE 16 SUMMARY OF AIR POLLUTANT EMISSIONS IN CASS COUNTY, 1968 (Tons/Year)

Source Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Transportation					
Road Vehicles	140	240	25,810	2,070	1,590
Other	40	170	3,900	890	420
Subtotal	180	410	29,710	2,960	2,010
Stationary Fuel Combustion					
Industry	30	10	N	N	110
Steam-Electric	1,900	4,490	30	10	1,000
Residential	500	90	20	30	190
Commercial and Institutional	1,670	1,990	670	140	410
Subtotal	4,100	6,580	720	180	1,710
Solid Waste Disposal					
Incineration	10	80	350	10	20
Open Burning	10	110	570	200	70
Subtotal	20	190	920	210	90
Industrial Process Losses	0	12,160	360	0	0
Evaporative Losses	--	--	--	3,830	--
TOTAL ALL SOURCES*	4,300	19,340	31,710	7,180	3,800

*Totals have been rounded.

N = Negligible

TABLE 17 SUMMARY OF AIR POLLUTANT EMISSIONS IN CLAY COUNTY, 1968

(Tons/Year)

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Transportation					
Road Vehicles	90	150	17,370	1,390	1,080
Other	20	60	30	70	110
Subtotal	110	210	17,400	1,460	1,190
Stationary Fuel Combustion					
Industry	1,590	6,410	150	50	1,090
Steam-Electric	0	0	0	0	0
Residential	290	50	10	20	100
Commercial and Institutional	480	400	130	30	280
Subtotal	2,360	6,860	290	100	1,470
Solid Waste Disposal					
Incineration	10	50	200	N	10
Open Burning	10	120	670	230	90
Subtotal	20	170	870	240	100
Industrial Process Losses	0	6,640	0	0	0
Evaporative Losses	--	--	--	2,120	--
TOTAL ALL SOURCES*	2,490	13,880	18,560	3,920	2,760

*Totals have been rounded.

N = Negligible

EMISSIONS BY GRID

For the purpose of defining the geographical variation of air pollutant emissions in the Study Area, the resulting emissions were apportionned on the grid coordinate system. The emissions were divided into two source groups--point and area sources. Sixty point sources are identified individually with respect to location and emissions. Each of these point sources emitted more than 0.1 tons per average annual day of any pollutant.

CONTRIBUTIONS OF POINT AND AREA SOURCES

Figure 5 shows the location of all point sources in the area. Collectively the 60 point sources account for 70 percent of all sulfur oxides emissions, 95 percent of particulate matter, 36 percent of nitrogen oxides, 34 percent of hydrocarbons, and only 10 percent of carbon monoxide. The percentage contribution to carbon monoxide emissions is low because motor vehicles, which are area sources, contribute 86 percent of the total carbon monoxide emissions. Table 18 presents the emissions of point sources. Each source is identified by source category, grid number and horizontal and vertical coordinates. The emissions of sulfur oxides, particulates, carbon monoxide, hydrocarbons, and nitrogen oxides are shown for an average annual day, average winter day (December, January, February), and average summer day (June, July, August). The appendix presents the method of calculating these three averages.

Area sources are sources of emissions that are insignificant by themselves, but as a group may emit a large portion of the area's total pollution. Examples of area sources are motor vehicles, residences, light commercial and industrial establishments and backyard burning. The emissions from area sources have been added to that for point sources to obtain total emissions from all sources by grid, as shown in Table 19. The emissions from all sources are also shown for an annual average, winter and summer day.

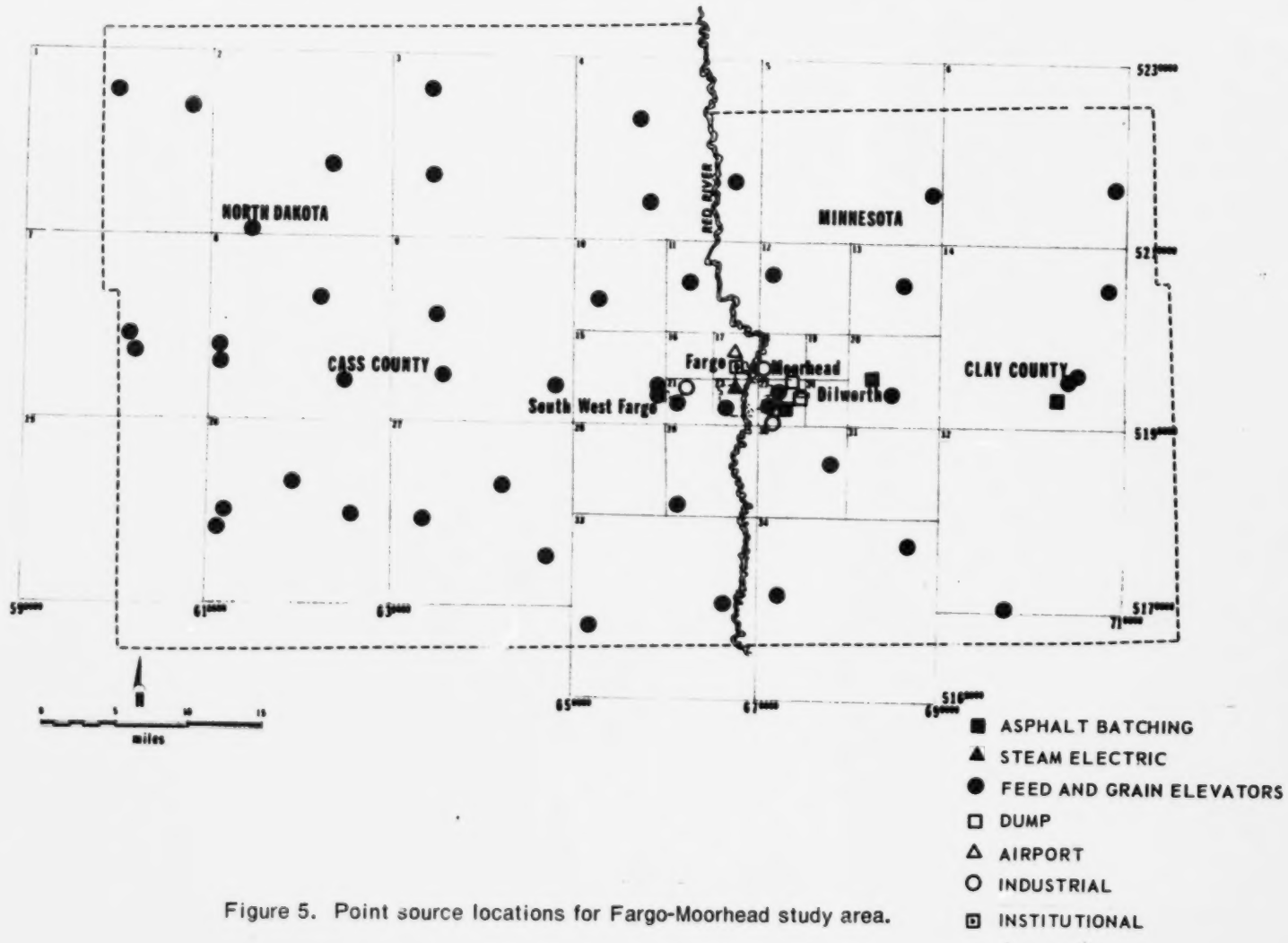

Figure 5. Point source locations for Fargo-Moorhead study area.

TABLE 18 SUMMARY OF POINT SOURCE EMISSIONS IN THE FARGO-MOORHEAD STUDY AREA, 1968 (Tons/Day)

Source Category	Grid	HC	VC	SOx S	SOx W	SOx A	PART. S	PART. W	PART. A	CO S	CO W	CO A	HC S	HC W	HC A	NOx S	NOx W	NOx A
Industrial	1	6090	52240	0.0	0.0	0.0	0.72	0.24	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	1	5990	52250	0.0	0.0	0.0	1.31	0.43	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	2	6160	52110	0.0	0.0	0.0	0.37	0.12	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	2	6220	52190	0.0	0.0	0.0	1.53	0.50	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	3	6350	52180	0.0	0.0	0.0	1.05	0.34	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	3	6330	52390	0.0	0.0	0.0	5.42	1.80	3.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	4	6660	52160	0.0	0.0	0.0	1.79	0.59	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	4	6560	52120	0.0	0.0	0.0	0.99	0.34	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	4	6550	52240	0.0	0.0	0.0	0.15	0.05	0.10	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0.00	0.00
Industrial	5	6895	52160	0.0	0.0	0.0	2.69	0.89	1.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	6	7090	52180	0.0	0.0	0.0	2.69	0.89	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	7	6010	51980	0.0	0.0	0.0	0.48	0.16	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	7	6010	51985	0.0	0.0	0.0	0.49	0.16	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	8	6220	52050	0.0	0.0	0.0	1.82	0.60	1.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	8	6110	51960	0.0	0.0	0.0	0.48	0.16	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	8	6110	51965	0.0	0.0	0.0	0.59	0.20	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0 00	0.00	0.00
Industrial	8	6260	51960	0.0	0.0	0.0	2.03	0.67	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	9	6350	52010	0.0	0.0	0.0	3.41	1.13	2.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	9	6360	51950	0.0	0.0	0.0	2.60	0.86	1.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	9	6480	51940	0.0	0.0	0.0	0.27	0.09	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	10	6520	52020	0.0	0.0	0.0	1.14	0.37	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE 18 SUMMARY OF POINT SOURCE EMISSIONS (cont.)

Source Category	Grid	HC	VC	SOx			PART.			CO			HC			NOx		
				S	W	A	S	W	A	S	W	A	S	W	A	S	W	A
Industrial	11	6620	52050	0.0	0.0	0.0	0.44	0.15	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	12	6710	52060	0.0	0.0	0.0	1.49	0.49	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	13	6875	52050	0.0	0.0	0.0	0.55	0.15	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	14	7050	51940	0.0	0.0	0.0	1.69	0.59	1.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	14	7055	51940	0.0	0.0	0.0	0.90	0.30	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	14	7090	52070	0.0	0.0	0.0	0.90	0.30	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	14	7040	51930	0.0	0.0	0.0	1.19	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	15	6590	51930	0.0	0.0	0.0	3.73	1.24	2.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	15	6590	51940	0.0	0.0	0.0	1.53	0.50	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Institutional	17	6670	51960	0.0	7.7	3.7	0.00	10.04	4.83	0.00	3.41	1.64	0.00	0.68	0.32	0.00	0.54	0.26
Airport	17	6670	51975	0.0	0.0	0.0	0.19	0.19	0.19	10.52	10.52	10.52	2.10	2.10	2.10	0.59	0.59	0.59
Industrial	18	6710	51965	0.0	8.7	4.2	0.00	36.37	18.63	0.00	0.86	0.41	0.00	0.28	0.13	0.00	5.74	2.76
Dump	18	6725	51960	0.0	0.0	0.0	0.10	0.10	0.10	0.58	0.58	0.58	0.20	0.20	0.20	0.07	0.07	0.07
Industrial	20	6830	51940	0.0	0.0	0.0	0.70	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	20	6845	51940	0.0	0.0	0.0	0.90	0.30	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	21	6610	51940	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	8.39	2.80	5.50	0.00	0.00	0.00
Industrial	21	6610	51930	0.0	0.0	0.0	1.53	0.50	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	22	6680	51940	0.0	0.0	0.0	0.70	0.70	0.70	0.99	0.99	0.99	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	22	6660	51940	0.0	0.0	0.0	0.44	0.15	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Steam-Electric	22	6675	51940	3.2	7.4	5.2	7.46	17.40	12.30	0.04	0.09	0.06	0.01	0.03	0.02	1.66	3.89	2.74

TABLE 18 SUMMARY OF POINT SOURCE EMISSIONS (cont.)

Source Category	Grid	HC	VC	SOx			PART.			CO			HC			NOx	
				S	W	A	S	W	A	S	W	A	S	W	A	S	W	A
Industrial	23	6715	51925	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	3.15	1.04	2.09	0.00	0.00	0.00
Industrial	23	6715	51940	0.0	0.0	0.0	0.80	0.30	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	23	6715	51945	0.0	0.0	0.0	2.79	0.92	1.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	23	6720	51925	0.0	0.0	0.0	1.49	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dump	23	6740	51930	0.0	0.0	0.0	0.02	0.02	0.02	0.11	0.11	0.11	0.04	0.04	0.04	0.01	0.01	0.01
Industrial	26	6100	51790	0.0	0.0	0.0	1.77	0.64	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	26	6110	51800	0.0	0.0	0.0	0.99	0.33	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	26	6260	51820	0.0	0.0	0.0	2.38	0.79	1.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	26	6190	51850	0.0	0.0	0.0	0.79	0.26	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	27	6480	51740	0.0	0.0	0.0	0.90	0.30	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	27	6420	51850	0.0	0.0	0.0	0.89	0.30	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	27	6320	51820	0.0	0.0	0.0	0.49	0.16	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	29	6605	51805	0.0	0.0	0.0	5.78	1.92	3.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	30	6790	51830	0.0	0.0	0.0	0.45	0.15	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	32	6970	51695	0.0	0.0	0.0	2.24	0.74	1.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	33	6680	51710	0.0	0.0	0.0	1.37	0.45	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	33	6510	51680	0.0	0.0	0.0	0.84	0.28	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	34	6725	51700	0.0	0.0	0.0	1.49	0.49	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	34	6875	51760	0.0	0.0	0.0	0.93	0.31	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE 19 SUMMARY OF AIR POLLUTANT EMISSIONS FROM ALL SOURCES IN THE FARGO-MOORHEAD STUDY AREA, 1968 (Tons/Day)

Area	Land Area (sq. Mi.)	SOx			PART.			CO			HC			NOx		
		S	W	A	S	W	A	S	W	A	S	W	A	S	W	A
1	154.4	0.0	0.1	0.0	2.1	0.7	1.4	0.9	0.6	0.8	0.2	0.1	0.2	0.1	0.1	0.1
2	154.4	0.0	0.1	0.1	2.0	0.7	1.3	2.2	1.4	1.8	0.4	0.3	0.3	0.2	0.2	0.2
3	154.4	0.0	0.2	0.1	6.6	2.3	4.4	2.4	1.5	2.0	0.5	0.3	0.4	0.3	0.2	0.3
4	154.4	0.0	0.1	0.1	3.1	1.1	2.2	2.3	1.5	2.0	0.4	0.3	0.4	0.2	0.2	0.2
5	154.4	0.0	0.1	0.1	2.7	1.0	1.9	1.5	1.0	1.3	0.3	0.2	0.3	0.1	0.1	0.1
6	154.4	0.0	0.2	0.1	2.7	1.0	1.9	2.0	1.3	1.7	0.4	0.3	0.3	0.2	0.2	0.2
7	154.4	0.0	0.1	0.0	1.0	0.4	0.7	1.9	1.2	1.6	0.4	0.2	0.3	0.2	0.2	0.2
8	154.4	0.0	0.1	0.1	5.0	1.7	3.4	3.4	2.1	2.8	0.6	0.4	0.5	0.4	0.3	0.3
9	154.4	0.0	0.2	0.1	6.4	2.2	4.3	3.5	2.2	2.9	0.7	0.5	0.6	0.4	0.3	0.4
10	38.6	0.0	0.0	0.0	1.2	0.4	0.8	1.0	0.6	0.9	0.2	0.1	0.2	0.1	0.1	0.1
11	38.6	0.0	0.1	0.0	0.5	0.2	0.3	1.6	1.0	1.3	0.3	0.2	0.3	0.2	0.1	0.2
12	38.6	0.0	0.1	0.1	1.5	0.6	1.1	1.8	1.2	1.5	0.3	0.2	0.3	0.3	0.1	0.2
13	38.6	0.0	0.0	0.0	0.6	0.2	0.4	0.6	0.4	0.5	0.1	0.1	0.1	0.1	0.1	0.1
14	154.4	0.0	0.4	0.2	4.8	1.5	3.2	4.2	2.7	3.5	0.8	0.6	0.7	0.4	0.4	0.4
15	38.6	0.0	0.1	0.0	5.3	1.8	3.6	1.3	0.8	1.1	0.3	0.2	0.2	0.1	0.1	0.1
16	9.6	0.0	0.1	0.0	0.0	0.1	0.1	0.7	0.4	0.6	0.2	0.1	0.1	0.1	0.1	0.1
17	9.6	0.1	8.7	4.2	0.4	10.8	5.4	19.1	19.5	19.4	3.6	3.9	3.8	1.3	2.3	1.8
18	9.6	0.0	8.9	4.3	0.1	36.6	18.8	3.1	3.1	3.2	0.6	0.8	0.7	0.2	6.0	3.0
19	9.6	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.3	0.4	0.1	0.1	0.1	0.0	0.0	0.0
20	38.6	0.0	0.1	0.1	1.6	0.4	1.0	0.8	0.6	0.7	0.2	0.1	0.2	0.1	0.1	0.1
21	9.6	0.0	0.2	0.1	1.6	0.6	1.1	1.2	0.8	1.0	8.7	3.0	5.7	0.1	0.2	0.2
22	9.6	3.5	10.4	6.8	8.2	19.3	13.6	50.6	32.6	42.8	6.5	4.7	5.7	4.1	7.6	5.8

TABLE 19 SUMMARY OF AIR POLLUTANT EMISSIONS FROM ALL SOURCES (cont.)

Grid	Land Area (Sq. Mi.)	SOx			PART.			CO			HC			NOx		
		S	W	A	S	W	A	S	W	A	S	W	A	S	W	A
23	9.6	0.2	2.1	1.1	5.6	2.8	4.2	31.4	20.0	26.5	7.1	3.9	5.6	1.4	2.2	1.8
24	9.6	0.0	0.2	0.1	0.1	0.2	0.1	0.5	0.4	0.4	0.2	0.2	0.2	0.1	0.2	0.2
25	154.4	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.5	0.7	0.2	0.1	0.1	0.1	0.1	0.1
26	154.4	0.0	0.1	0.1	6.0	2.1	4.0	2.2	1.4	1.9	0.4	0.3	0.4	0.2	0.2	0.2
27	154.4	0.0	0.1	0.1	2.3	0.8	1.6	2.0	1.3	1.7	0.4	0.3	0.3	0.2	0.2	0.2
28	38.6	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.6	0.8	0.2	0.1	0.2	0.1	0.1	0.1
29	38.6	0.0	0.1	0.0	5.8	2.0	3.9	1.6	1.0	1.3	0.3	0.2	0.3	0.2	0.1	0.2
30	38.6	0.0	0.1	0.1	0.5	0.2	0.4	1.9	1.2	1.6	0.4	0.2	0.3	0.2	0.2	0.2
31	38.6	0.0	0.1	0.0	0.0	0.0	0.0	1.5	1.0	1.3	0.3	0.2	0.2	0.1	0.1	0.1
32	154.4	0.0	0.4	0.2	2.3	1.0	1.7	2.7	1.8	2.3	0.6	0.4	0.5	0.3	0.4	0.3
33	154.4	0.0	0.2	0.1	2.3	0.8	1.6	2.4	1.5	2.0	0.5	0.3	0.4	0.3	0.2	0.2
34	154.4	0.0	0.2	0.1	2.5	0.9	1.7	3.9	2.4	3.3	0.7	0.5	0.6	0.4	0.3	0.4

EMISSION DENSITIES

In order to provide a visual representation of the emissions of pollutants by grids, emission density maps have been prepared. Emission densities were obtained by summing the annual area and point source emissions for each grid and dividing this total by the land area of the grid. Figures 6 through 10 show the variation in emission densities for the respective grids throughout the Study Area. As expected the emissions generally follow the pattern and degree of urbanization. Emission denisties for carbon monoxide and hydrocarbons are higher in the grids with the higher populations and corresponding higher vehicular activity.

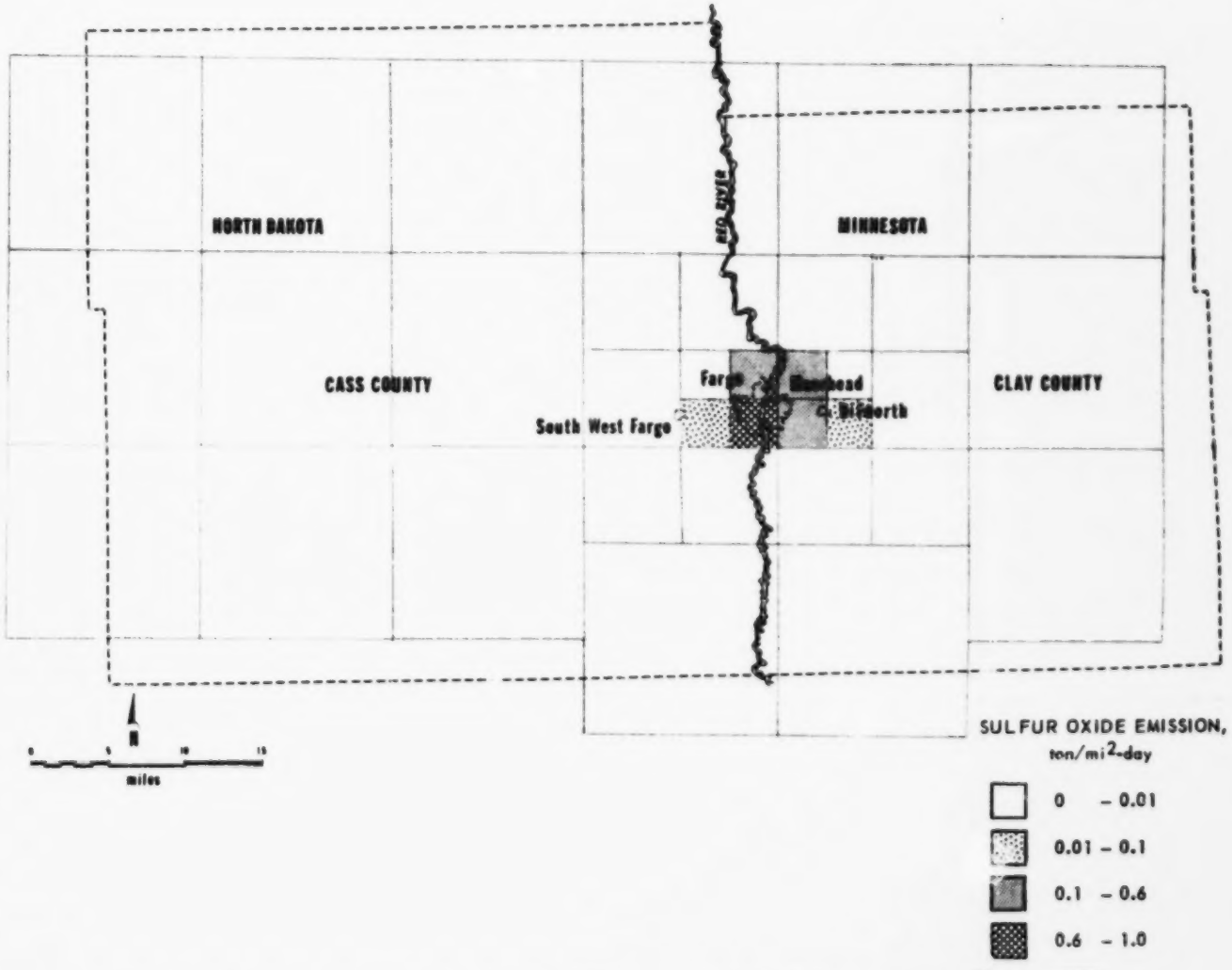

Figure 6. Sulfur oxide emission density from all sources for Fargo-Moorhead study area.

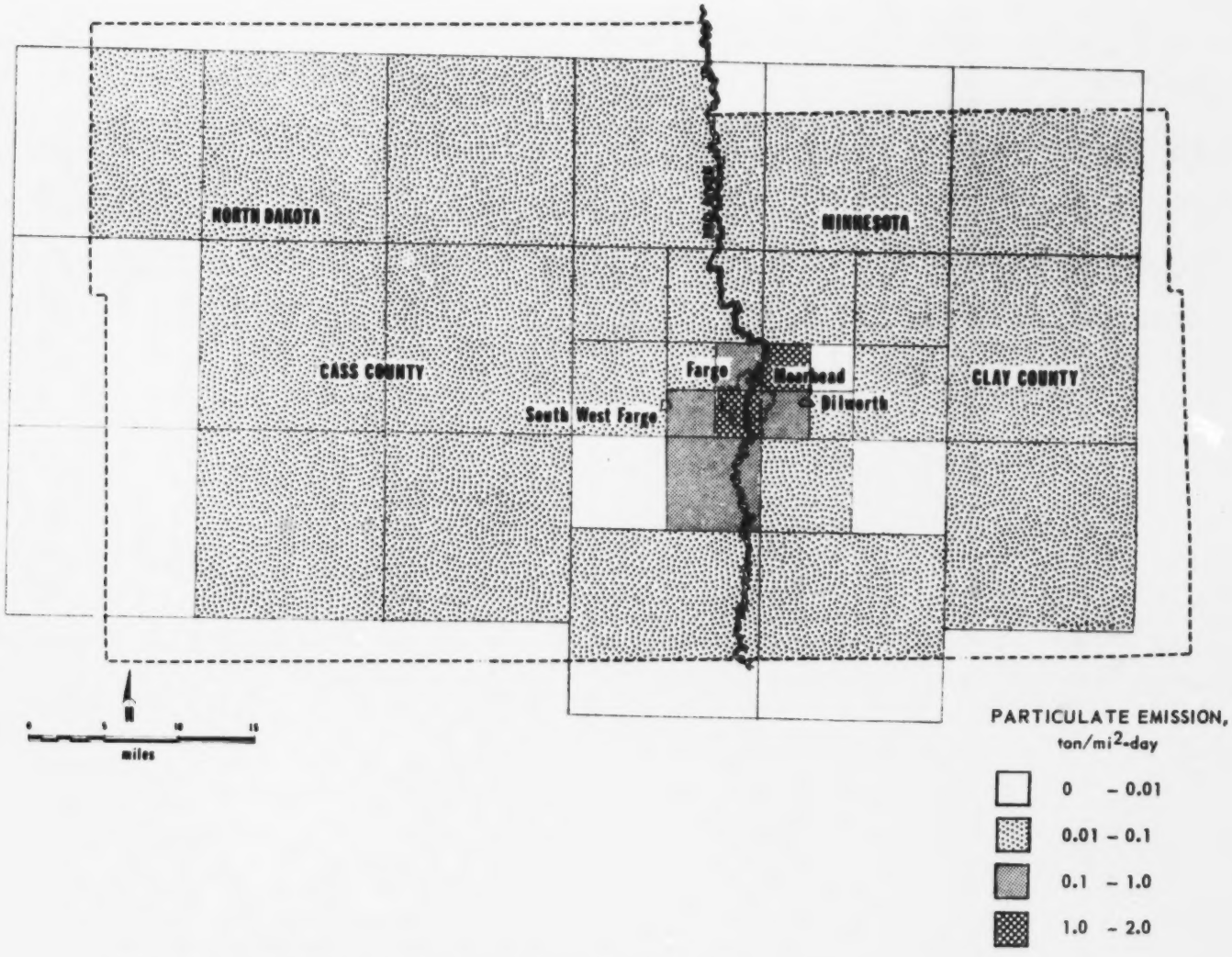

Figure 7. Particulate emission density from all sources for Fargo-Moorhead study area.

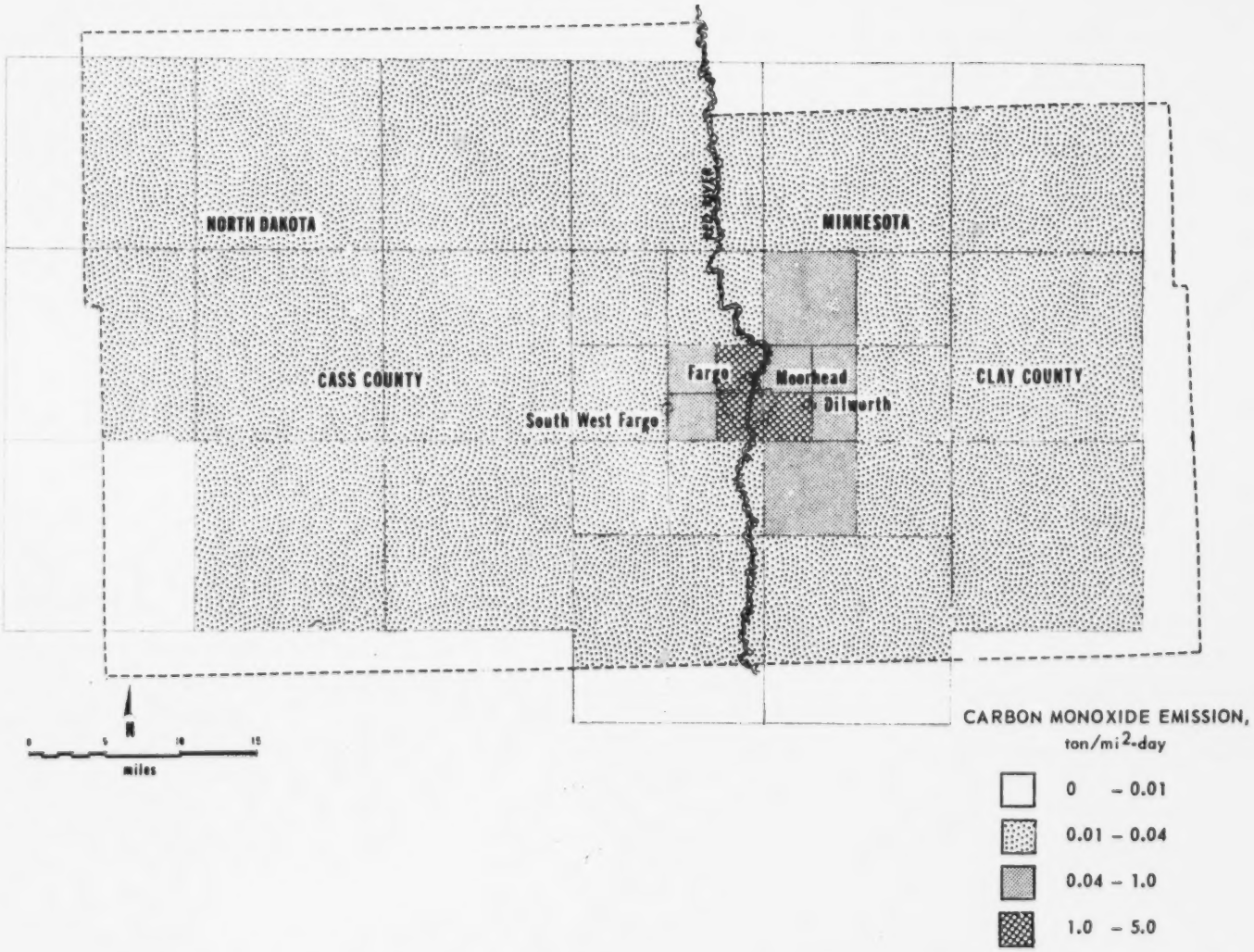

Figure 8. Carbon monoxide emission density from all sources for Fargo-Moorhead study area.

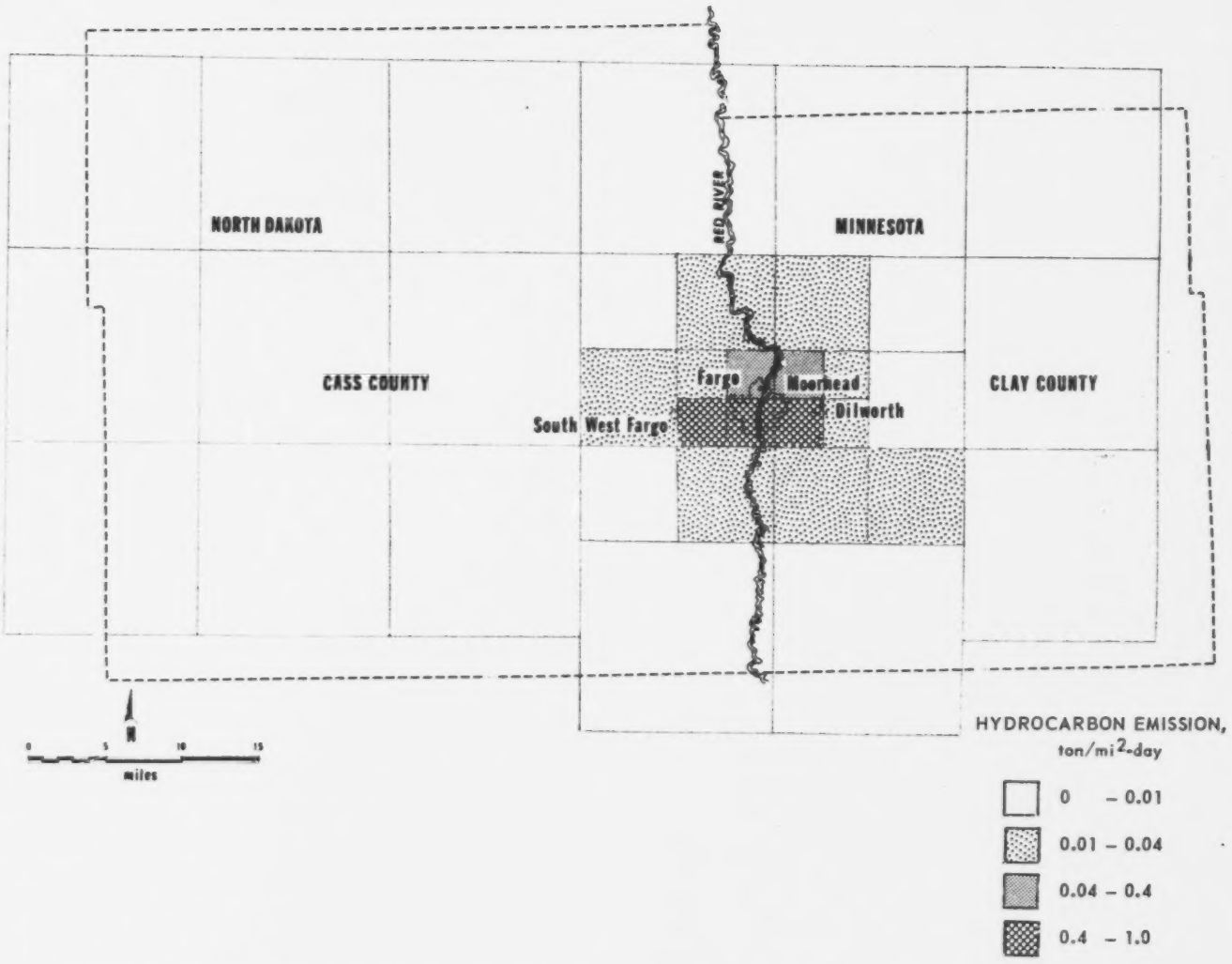

Figure 9. Hydrocarbon emission density from all sources for Fargo-Moorhead study area.

Figure 10. Nitrogen oxide emission density from all sources for Fargo-Moorhead study area.

REFERENCES

1. Ozolins, Guntis and Smith, Raymond, Rapid Survey Technique for Estimating Community Air Pollution Emissions, DHEW, PHS, October, 1966.

2. Duprey, R. L., Compilation of Air Pollutant Emission Factors, United States, DHEW, PHS, 1968.

3. County and City Data Book 1967, United States Department of Commerce, April, 1967.

4. Census of Housing, United States Department of Commerce, Bureau of the Census, 1960.

5. Bulletin No. 155, Petroleum Products and Antifreeze 1968 Report, State Laboratories Commission, Bismarck, North Dakota.

6. North Dakota Traffic Report 1968, North Dakota State Highway Department, Planning and Research.

7. Duprey, op. cit., p. 46.

APPENDIX

METHOD FOR CALCULATING SUMMER, WINTER AND ANNUAL AVERAGE EMISSIONS FOR FUEL CONSUMPTION IN STATIONARY SOURCES

YEARLY AVERAGE (A)

$$A = \frac{\text{Fuel Consumed} \times \text{Emission Factor (E. F.)}}{\text{Days of Operation}}$$

e.g. A plant consumed 100,000 tons of coal in 1967 while operating 365 days. The total degree days for the area was 4,800 and 2,800 for the three winter months. The plant was estimated to use 15 percent of the fuel for space heating and 85 percent for process heating. From this information, the annual average emission for carbon monoxide would be the following:

$$A = \frac{100{,}000 \text{ Tons/year} \times 3 \text{ lbs. CO/Ton coal}}{365 \text{ Days/year} \times 2{,}000 \text{ lb./Ton}}$$

$$A = 0.41 \text{ Ton/Day}$$

WINTER AVERAGE (W)

$$W = \frac{\text{Fuel Consumed} \times \text{E.F.}}{\text{Days of Winter Operation}} \times \frac{\text{Winter Degree Days}}{\text{Total Degree Days}} \times \text{\% Fuel Used for space heating}$$

$$+ \frac{\text{Fuel Consumed} \times \text{E.F.}}{365} \times \text{\% Fuel used for process heating}$$

$$W = \left[\frac{100{,}000 \times 2{,}800}{90 \times 4{,}800} \times 0.15 + \frac{100{,}000}{365} \times 0.85\right] \frac{3}{2{,}000}$$

$$W = 0.49 \text{ Ton/Day}$$

SUMMER AVERAGE (S)

$$S = \frac{\text{Fuel Consumed} \times \text{E.F.}}{\text{Days of Summer Operation}} \times \frac{\text{Summer Degree Days}}{\text{Total Degree Days}} \times \text{\% Fuel Used for space heating}$$

$$+ \frac{\text{Fuel Consumed} \times \text{E.F.}}{365} \times \text{\% Fuel used for process heating}$$

$$S = \left[\frac{100{,}000}{90} \times \frac{0}{4{,}800} \times 0.15 + \frac{100{,}000}{365} \times 0.85\right] \frac{3}{2{,}000}$$

$$S = 0.35 \text{ Ton/Day}$$